

GENERAL SPECIFICATION

Safety

GS EP SAF 337

Passive Fire Protection: basis of design

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1. Scope

1.1 Purpose

The purpose of this General Specification is to set out Company's philosophy and requirements for the installation, selection and use of Passive Fire Protection (PFP) systems for onshore and offshore installations. For particular concerns related to F(P)SOs and LNG installations, refer to [GS EP SAF 380](#) and [GS EP SAF 521](#).

1.2 Applicability

This General Specification is not retroactive. It applies to new facilities and major modifications or extensions of the existing installations. The present document does not cover the fire rating requirements for internal partitions in buildings (refer to [GS EP SAF 221](#)).

This specification defines the minimum requirements to onshore and offshore installations, in particular for:

- The identification of the PFP needs,
- The definition of PFP extents,
- The PFP performances,
- The PFP materials suitability with respect to different types of application.

For Quality Assurance and Quality Control refer to [GS EP COR 353](#).

For particular application of risers, refer also to [GS EP COR 230](#) and [GS EP COR 231](#).

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

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External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
API RP 14G	Recommended Practice for Fire Prevention and Control on Fixed Open-type offshore production platforms
API RP 2218	Fireproofing Practices in Petroleum and Petrochemical Processing Plants
IMO SOLAS	International Convention for the Safety Of Life At Sea (SOLAS), 1974 and subsequent amendments
IMO SOLAS Chapter II-2 Part C. Regulation 4	Probability of ignition, Chapter II-2, Part C IMO SOLAS
IMO SOLAS Chapter II-2 Part C. Regulation 9	Containment of fire, Chapter II-2, Part C IMO SOLAS
ISO 834-1	Fire resistance tests - Elements of building construction – Part 1: General requirements
ISO 10497	Testing of valves - Fire type-testing requirements
ISO 13702	Petroleum and natural gas industries - Control and mitigation of fires and explosion on offshore production installations. Requirements and guidelines
ISO 14692-1	Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 1: Vocabulary, symbols, applications and materials
ISO 14692-2	Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 2: Qualification and manufacture
ISO 22899-1	Determination of the resistance to jet fires of passive fire protection materials – Part 1: General requirements
NFPA 30	Flammable and Combustible Liquids Code
NFPA 33	Standard for Spray Application Using Flammable or Combustible Materials
NFPA 58	Liquefied Petroleum Gas Code
NORSOK S-001	NORSOK Standard S-001. Technical safety. Edition 4, February 2008
OTI 95634	Offshore Technology Report – Jet fire resistance test of passive fire protection materials, prepared by the Jet Fire Test Working Group for the Health and Safety Executive.
Resolution A.753 (18)	Guidelines for the application of plastic pipes on ships, adopted on 4 November 1993. IMO SOLAS

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Reference	Title
Resolution A.754 (18)	Recommendation on fire resistance tests for "A", "B" and "F" class divisions, adopted on 4 November 1993. IMO SOLAS
UKOOA	United Kingdom Offshore Operators Association – Fire and Explosion Hazard Management Guidelines, March 1995
UL 1709	Rapid rise fire tests of protection materials for structural steel, 2011

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP COR 230	External laminated glass fibre/resin based coating for risers of sea line
GS EP COR 231	External elastomer based coating for risers of sea line
GS EP COR 353	Design and application of passive fire protection coatings
GS EP PLR 100	Submarine pipeline systems
GS EP SAF 041	Technological Risk Assessment Methodology
GS EP SAF 021	Layout
GS EP SAF 221	Safety rules for buildings
GS EP SAF 253	Impacted area, restricted area and fire zones
GS EP SAF 261	Emergency Shut Down and Emergency De-Pressurisation (ESD & EDP)
GS EP SAF 262	Pressure protection relief and hydrocarbon disposal systems
GS EP SAF 341	Location and protection of onshore hydrocarbon storage
GS EP SAF 380	Safety Engineering requirements for an F(P)SO
GS EP SAF 521	Safety specific requirements for LNG onshore liquefaction plants and export
GS EP STR 100	Offshore steel structures – General
GS EP STR 102	Design of offshore topside structure
GS EP STR 108	Requirements for evaluation of finite element analysis and results

3. Terms and definitions

There are three types of statements in this specification: “shall”, “should” and “may”. They shall be understood as follows:

Shall Is to be understood as mandatory. Any deviation from a “shall” statement requires a derogation approved by the Company.

Should Is to be understood as strongly recommended to comply with the requirements of the specification. Alternatives shall provide a similar level of protection and this shall be documented.

May Is used where alternatives are equally acceptable.

For the purpose of this document, only the following terms and definitions apply:

Boiling Liquid Expanding Vapour Explosion (BLEVE)	Sudden rupture due to fire impingement of a vessel and/or system containing liquefied flammable gas under pressure. The pressure burst and the flashing of the liquid to vapour creates a blast wave and potential missile damage, and immediate ignition of the expanding fuel-air mixture leads to intense combustion creating a fireball (UKOOA).
Company	Total Exploration & Production
Emergency De-Pressurization (EDP)	Control actions undertaken to depressurize equipment or process down to a pre-defined threshold (generally 7 barg or 50% of design pressure whichever is less) in a given period of time (generally 15 minutes) in response to a hazardous situation (Company from ISO 13702).
Emergency Response (ER)	Action taken by personnel on or off the installation to control or mitigate a hazardous event or initiate and execute abandonment (ISO 13702).
Escalation	Spread of the impact of a hazardous event to equipment or other areas thereby causing an increase in the consequences of the initial event (e.g domino effect).
Evacuation, Escape and Rescue (EER)	General term used to describe the range of possible actions including escape, muster refuge, evacuation, escape to the sea and rescue/recovery (ISO 13702).
Fire rating	Time during which a structure or component will provide prescribed resistance to transmission of heat, passage of flame, smoke and toxic gases and structural failure (Company concept).
Flammable liquid	Is considered as flammable liquid, liquid handled above its flash point or liquid with a flash point lower than 60°C (NFPA 30).
Flash point	Minimum temperature at which a liquid produces vapour in sufficient concentration to form an ignitable mixture with air near the surface of the liquid (NFPA 30).
Fluid category class	As per NFPA 30 , hydrocarbons fluids are classified as follows: - Fluid class IA: liquid having a flash point below 22.8°C: - IA: Atmospheric boiling point below 37.8°C;

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	○ IB: Atmospheric boiling point above 37.8°C. • Fluid class IC: Liquid having a flash point at or above 22.8°C and below 37.8°C; • Fluid class II: Liquid having a flash point at or above 37.8°C and below 60°C; • Fluid class IIIA: Liquid having a flash point at or above 60°C and below 93°C; • Fluid class IIIB: Liquid having a flash point at or above 93°C.															
Glass-fibre-reinforced epoxy (GRE)	Epoxy resin-based composite that is reinforced with glass fibre (ISO 14692-1)															
Glass-fibre-reinforced plastic (GRP)	Polymeric resin-based composite that is reinforced with glass fibre. (Company from ISO 14692-1)															
Not permanently / permanently manned rooms	These definitions for rooms can be summarized as follows (Company concept): <table><tr><td></td><td colspan="2">Time to access</td></tr><tr><td>Personnel presence</td><td>≤ 5 minutes</td><td>> 5 minutes</td></tr><tr><td>No routine requirement</td><td>Unmanned</td><td>Isolated</td></tr><tr><td>Routine checks ▫ once per day - or ▫ once per shift </td><td>Not permanently manned</td><td>Isolated</td></tr><tr><td>Permanent occupancy ▫ 50 % of total time per day - or ▫ 25% of total time per week </td><td>Permanently manned</td><td>NA</td></tr></table>		Time to access		Personnel presence	≤ 5 minutes	> 5 minutes	No routine requirement	Unmanned	Isolated	Routine checks ▫ once per day - or ▫ once per shift	Not permanently manned	Isolated	Permanent occupancy ▫ 50 % of total time per day - or ▫ 25% of total time per week	Permanently manned	NA
	Time to access															
Personnel presence	≤ 5 minutes	> 5 minutes														
No routine requirement	Unmanned	Isolated														
Routine checks ▫ once per day - or ▫ once per shift	Not permanently manned	Isolated														
Permanent occupancy ▫ 50 % of total time per day - or ▫ 25% of total time per week	Permanently manned	NA														
Not permanently manned installation	For this type of installations, no planned overnight stays of personnel shall be carried-out (Company concept).															
Passive Fire Protection (PFP)	Any fire protection system or component, which, by its inherent nature, plays an inactive role in the protection of personnel and property from damage by fire. Passive fire protection functions independently of a requirement for human, mechanical, or other intervention to initiate a consequential response (API RP 14G).															
Permanently manned installation	Fixed stand-alone offshore oil & gas production installation on which people are routinely accommodated, or which is occupied continuously during normal operations (Company concept).															
Pool fire	Combustion of flammable or combustible liquid spilled and retained on a surface (ISO 13702).															

4. General requirements for passive fire protection

The role of PFP is, first of all, a role of protection of personnel, of EER system to ensure evacuation can be completed in a safely manner and of the environment against hydrocarbons fires that could occur on the installation.

PFP has also a role of mitigation to protect the emergency functions (isolation, depressurization, active fire protection, etc.) to maintain them operable and efficient until, if needed, evacuation is completed and to minimize fire escalation.

PFP application is then mandatory on equipment and/or structures exposed to a fire that could lead to their integrity loss and either:

- being able to generate ALARP or 'first priority' risk levels (as per **GS EP SAF 041**) for the safety to life and/or for the environment, or
- participating in a significant way to the phenomenon of escalation and then leading to ALARP or 'first priority' risk levels, or
- being able to hinder EER operations (particularly for offshore).

Asset protection issues have to be applied in accordance with affiliate asset policy. This decision has to be made in the earliest phases of the Project and stated in the Statement of Requirements (SoR).

5. Basis of design for PFP installation on onshore structures and equipment

5.1 General

In line with **API RP 2218**, PFP of structures and equipment shall be based on pool fire scenarios (liquid hydrocarbons or liquefied gases if relevant according to climatic conditions).

As per **Company concept**, jet fire scenarios shall be considered only if they have been identified in the fire risks assessment as being a major contributor to escalation or being an obstacle to the EER operations. In each case, the duration of the jet fire scenario shall be assessed considering the mitigation measures (ESD and EDP) in place to evaluate as precisely as possible the impacts in terms of heating and weakening of the exposed structures or equipment.

The protection has to be defined in line with the identified fire scenario duration and with the maximum allowable temperature mentioned in section 5.4, table 2.

The respect of adequate safety distances between units/fire zones is the best way to protect equipment/structures against fires effects. If this is not achievable, a formal derogation to **GS EP SAF 253** and **GS EP SAF 021** shall be raised and protection can be made with:

- Active fire protection (deluge, curtains, etc.) and/or
- PFP materials.

5.2 Fire hazard evaluation

This evaluation shall be based on **API RP 2218** methodology (see figure 1):

- Identification of the “high-fire-potential” equipment to assist in hazard determination,
- Determination of fire scenario envelope based on the identification of high-fire potential equipment.

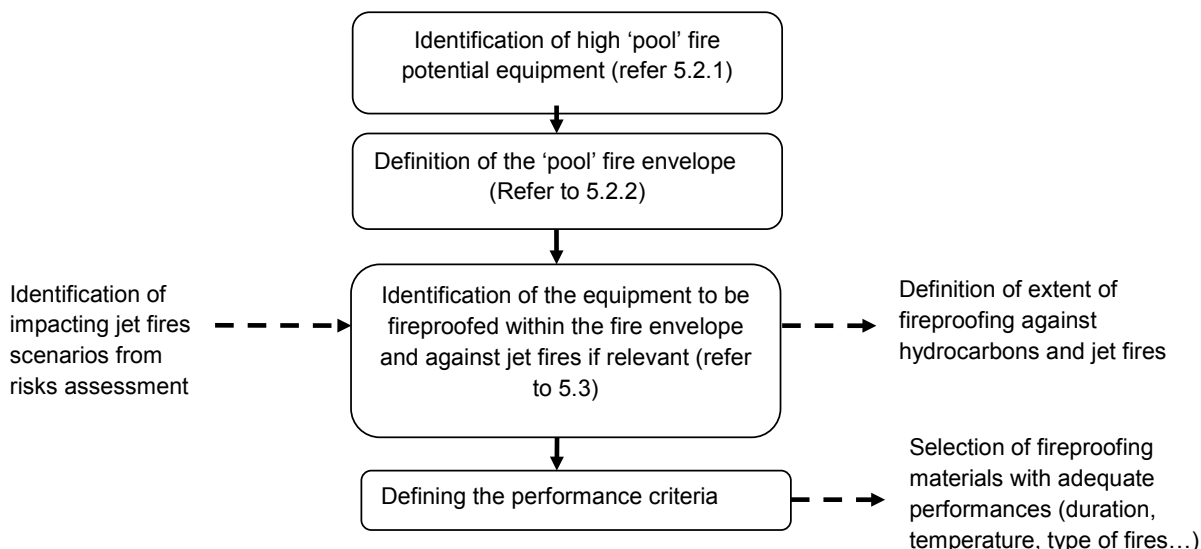


Figure 1: Workflow for PFP basis of design definition for an onshore installation

5.2.1 Fire potential equipment

The division of equipment into high, medium, low, and non-fire-potential is based on [API RP 2218](#) principles and comes from experience, technological knowledge and feedbacks from historical incidents. It shows that some types of equipment have a higher fire potential than others. These fire potential definitions include most types of hydrocarbon handling equipment that can release significant quantities of flammable fluids (mainly liquid).

Based on [API RP 2218](#) recommendations, the PFP definition strategy is based only on high-fire equipment. Following equipment shall be considered as high-fire potential equipment if they handle more than 5 m³ of flammable liquids:

- Fire heaters and boilers,
- Pumps with a flow rate above 45 m³/hr handling liquids above 8°C above their flash points,
- Large compressors equipped with above 5 m³ capacity lube-oil systems,
- Static equipment (vessels, heat exchangers, etc.) containing flammable liquids or, combustible liquids over 315°C or their auto-ignition temperature, whichever is less.

This list can be extended if the fire risks analysis shows that they are other high-fire potential equipment in the unit/installation.

5.2.2 Fire envelope determination

Company makes reference to the [API RP 2218](#) for the fire envelope dimensions. This is a three-dimensional space generated by high fire potential equipment that can release flammable fluids to form a significant size pool or that can feed a fire for a prolonged duration. By default, the fire envelope radius shall equal to 9 m (6-12 m according to [API RP 2218](#)) from the high-fire equipment and the vertical height to 9 m (or to the highest level supporting the equipment if it is a process equipment or a fin-fan cooler on pipe-rack), from the source of potential liquid spread or from any liquid spill accumulation point.

Any derogation to the above shall be duly demonstrated via a detailed fire risks assessment and shall be submitted to Company approval.

5.3 Equipment/structure concerned by PFP application within the fire envelope

Based on [API RP 2218](#) principles, the following type of equipment/structure if located within a fire envelope shall be fireproofed:

- Equipment/equipment supports with a large inventory (above 5m³) leading to a potential escalation.
- Steel structures supporting process equipment if there is a potential of escalation (significant hydrocarbons inventories handled in equipment) or if their collapses have the potential to damage nearby large equipment.
- Pipelines and supports for piperacks if there is a potential of escalation.
- Power (instrument and electrical cables) and control systems (air and hydraulic instrument lines).
- Emergency safety valves (ESDVs, SDVs, BDVs).

It is possible to mix different types of material to achieve the functionality of fire protection of equipment or structures (for instance: a steel structure may be protected by reinforced concrete until a certain height then by epoxy in case of weight issues). This has to be thought at very early stages of a Project.

5.3.1 Equipment/equipment supports

5.3.1.1 Equipments

Prolonged fire exposure of the equipment itself may result in a loss of its integrity and then contribute to the accident escalation, then a case by case analysis shall be carried-out to verify the need of fireproofing or not.

Fireproofing can be envisaged for LPG vessels that cannot be buried (refer to [GS EP SAF 341](#)). Intumescent epoxies are suitable for this application. However, cementitious coating is prohibited due to corrosion problems generation.

5.3.1.2 Equipments supports

Fireproofing of equipment supports shall be considered for:

- High-fire potential equipment itself,

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- Air coolers handling flammable liquids (above their auto-ignition temperature or above 315°C, whichever is lower). This type of equipment is subject to chimney effect and then shall be carefully protected.
 - If they are located at grade level, their supports shall be fireproofed.
 - If they are supported by a pipe-rack, fireproofing shall be applied to the supports, to the vertical structures up to the highest level supporting the air cooler as well as on horizontal stringer beams supporting vertical loads, regardless their elevation above grade (due to chimney effect).
- Large inventory (> 5 m³) process equipment (vessels, heat exchangers...) individual supports:
 - Skirts for vertical vessels: exterior surfaces to be protected and interior if there are valves or flanges inside or if there is an unsealed opening larger than 600 mm. If the vessels are elevated, then exposed steel legs have to be fireproofed to their full load bearing height. Lugs and brackets used to attach vertical vessels or exchangers shall be also fireproofed.
 - Steel saddles for horizontal vessels exceeding 750 mm in diameter if supports lengths are greater than 300 mm.
 - It is Company's policy to always protect the legs supporting the above ground LPG vessels (sphere or bullet). There is no need to fireproof the diagonal bracing as there are not bearing part of the structure. SDV's shall also be protected adequately. Intumescent epoxies are suitable for this application. Cementitious coating is prohibited due to corrosion problems generation.

Clearance shall be provided around active PFP epoxy materials to enable the complete development of their intumescence during the specified protection duration time. As a default value, the minimum clearance shall be assumed as 100 mm, but it has to be confirmed by PFP Supplier during further stages of the Project later (this is a variable depending on PFP product).

5.3.2 Steel structures

5.3.2.1 Supporting equipment

Structures that shall be fireproofed are:

- Structures supporting large inventory equipment (mainly fire-fire equipment) or
- Supporting equipment with the potential for escalation (by falling on high-fire potential equipment) or
- Supporting equipment containing toxic materials.

For equipment within the fire envelope, fire protection shall be applied to the vertical members and stability bracings and to all elements contributing to the horizontal stability of vertical members. This from grade to the level where the equipment is supported. Importance of structural members shall be assessed as per **GS EP STR 100**.

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For equipment higher than the fire envelope: structures contributing to the equipment load support have to be fireproofed from grade level up to the level nearest the upper level of the fire envelope.

In addition, if vessels are installed on fireproofed structures, equivalent protection shall be considered for the supporting elements: baseframe or skirts.

Clearance shall be provided around active PFP epoxy materials to enable the complete development of their intumescence during the specified protection duration time. As a default value, the minimum clearance shall be assumed as 100 mm but it has to be confirmed by PFP Supplier during further stages of the Project later (this is a variable depending on PFP product).

For a structure contained in a fire envelope with no high-fire equipment at the highest level, PFP can be applied on the last solid floor where no such equipment is situated so as to stop fire propagation. It avoids fireproofing all the structure within the fire envelope by creating a fire barrier.

5.3.2.2 Piperacks

In the fire envelope, fireproofing shall be considered for vertical and horizontal supports if they support piping containing flammable or toxic materials or if safety elements are located on it (SDVs, BDVs, deluge valves, deluge pipes, flare header, etc.). In such cases, PFP shall be considered up and including the first level, if it is above 9 m, or the level which is nearest above the 9 m elevation, if this level is lower.

PFP shall be not applied to knee and diagonal bracing designed only for wind or earthquake loads.

Where PFP is required for horizontal beams, the upper surface of the beam shall not be fireproofed for pipe movement reasons.

If air coolers are located on a top of pipe racks, the rules for air-coolers mentioned in paragraph 5.3.1 apply.

5.3.3 Piping

The protection of piping by using PFP shall be avoided as much as possible by limiting their exposure to potential fires (by adjusting their routings to respect the safety distances, by burying them, etc.).

However, if the above is not achievable and if analysis demonstrates they are vulnerable, piping related to a safety function service (firewater, flare header, etc.) and piping that will contribute to major escalation of the initial event (either by handling toxic materials or significant inventory of flammable fluids) shall be fireproofed.

The individual T columns, independent stanchions, columns with brackets shall be fireproofed if they support pipelines entering in the category detailed above even if they are located outside the main pipe rack.

When piping is hung by rods or springs type connections, then a “catch beam” shall be provided and fireproofed as well as its supports.

When the pipe is located on a piperack with such type of connections, then the piperack supports members shall be fireproofed up to the extent of the “catch beam”.

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5.3.4 Power and control systems

Power and control systems used to activate emergency safety functions shall be as less as possible exposed to any potential fire unless they are designed to fail safe during a fire exposure.

5.3.5 Emergency safety valves

The preferred solution is to use fire-safe certified material (valve, associated wiring and motor) that is designed to fail in a safe position during a fire exposure (to remain operable during enough time to reach this position). That means that this material has been tested for a 30 minutes hydrocarbon fire exposure and is suitable for this application ([ISO 10497](#)).

PPF shall be foreseen for all applications exceeding the fire-safe certification conditions. In such cases, it shall be applied on all elements of the valves (body and actuator) and on the wiring cables via removable items such as boxes, mattresses, etc.

5.4 Fire performances of PFP

PFP materials can be selected according to sections 8 and 9, detailed further in this document.

Any PFP materials shall be tested for the foreseen application according to relevant standards (refer to section 8).

As per **Company concept**, the fire rating with respect to the exposed equipment/structure shall be as per table 1:

Table 1: Fire rating for typical equipment/structures

Exposed element	Fire rating
Process steel structures and piping/piping supports	Minimum of 30 min (corresponding to the time for the mitigation measures to be in function and for structures to be efficiently cooled either by the emergency response team – if any - or by the deluge) or time corresponding to fire scenario duration, whichever is less.
LPG vessels supports	2 hours (NFPA 58).
Power and control systems	30 min minimum (UL 1709) or as specified by fire risks assessment.
Emergency safety valves	30 min minimum or as specified by fire risks assessment.

Fire scenario duration shall take into account the inventory, the burning rate of flammable liquids and also the mitigation measures in place if any.

The maximum surface temperatures that shall not be exceeded in the time frame given above are, for exposed element, those listed in table 2: